Public Safety Wireless Network

MOBILE SATELLITE SERVICES (MSS) REPORT

Foreword

This report is a primer for interested parties to become more familiar with the various aspects of mobile satellite services (MSS). It is not intended to reflect a government position or endorse a particular service provider or service; rather to provide broad industry information on MSS. We invite comments to ensure the most current information is included in our analyses.

If you have comments regarding the information contained in this document, please contact the Public Safety Wireless Network (PSWN) Program Management Office (PMO) at 800-565-PSWN.

Public safety agencies rely heavily on their private land mobile radio (LMR) networks for command, control, and communications. Public safety agencies also use commercial wireless services. The expansion of commercial wireless service offerings provides an unprecedented opportunity to examine these services as potential cost-effective alternatives or adjuncts to privately owned networks. In addition, commercial services may play a significant role in the development of an interoperable, seamless architecture for public safety users. Therefore, it is important to evaluate, assess, and maintain current information on the expanding commercial wireless marketplace.

This report examines Mobile Satellite Services (MSS) in terms of capabilities, coverage, costs, benefits, and limitations. The report includes a very high-level overview of basic MSS operations, features, and equipment.

What Is Mobile Satellite Service?

Mobile Satellite Service (MSS) is the term used to describe telecommunication services delivered via satellite to or from mobile users. MSS extends mobile communications beyond the range constraints of terrestrial based wireless systems and allows mobile-to-fixed and mobile-to-mobile voice and data communications worldwide. Until recently, the limited availability, cost and complexity limited use of MSS by the public. As a result, MSS has been employed primarily for unique communication applications and for serving niche markets. For example, MSS can be used in remote areas where wired networks do not exist or to serve public safety needs where terrestrial lines and portable radios are unavailable or ineffective during emergency situations.

Technology advances in satellite and antenna designs have overcome many of the limitations associated with providing satellite access to a mobile user. More sophisticated and powerful satellites and smaller, more user friendly terminals make mobile voice and data services available at very reasonable costs.

MSS is expected to fill the gaps in wireless voice telephony and complement existing terrestrial wireless or public switched network (PSN) services, while others will compete directly with existing terrestrial services. MSS services will include voice, low-speed data, fax, paging, high-speed data, and broadcast and video on demand; specific services may vary among MSS providers.

How Do MSS Networks Operate?

MSS systems are configured in global or national networks called satellite constellations. They have numerous Earth stations responsible to control and monitor the health and status of the satellites and to provide overall network management. Each satellite in the constellation provides coverage to a geographic area on the Earth called a footprint. Together, the entire satellite constellations provide satellite footprints that provide either global or national coverage, depending on the specific MSS system design.

Most communication satellites are little more than groups of active microwave repeaters located in the sky. Each repeater is known as a transponder. Each satellite has multiple transponders (usually between 20 to 50). A satellite receives signals from an Earth transmitter, amplifies them, translates them to another frequency, and then retransmits the signals back to an MSS gateway or subscriber terminal. Signal amplification is required at the satellite and the receiving gateway because signal degradation and strength loss occur when signals travel long distances through the atmosphere. Once the signal reaches Earth, MSS systems offer connectivity and interoperability with the PSN and cellular/PCS networks via satellite gateways. Three segments comprise a satellite system: the space segment, the user segment, and the control segment, as shown in Figure 1.

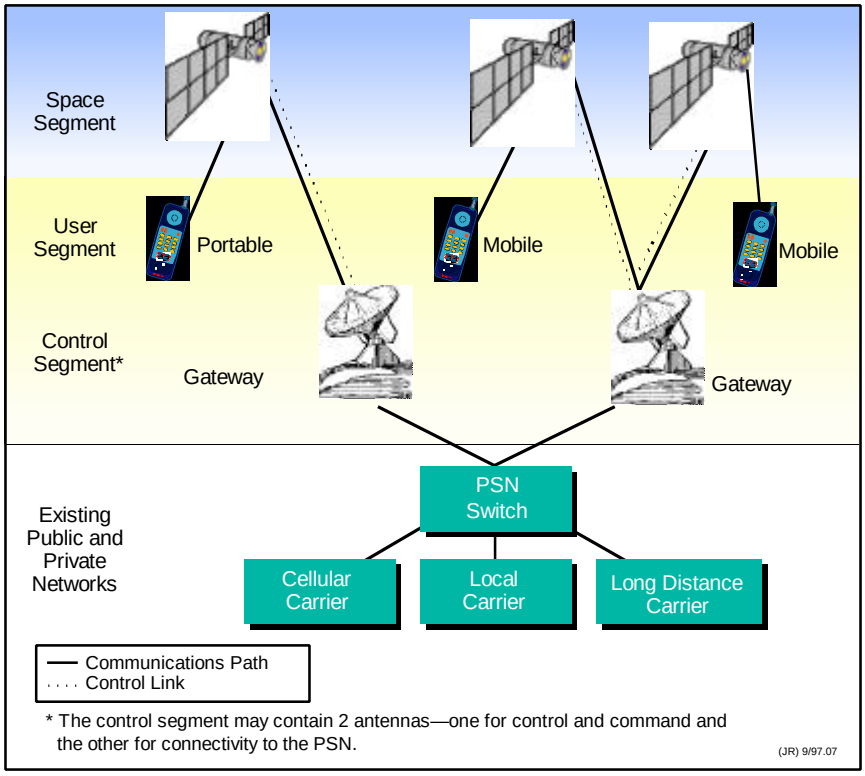

Figure 1
Basic MSS System

User Segment

The user segment consists of the terminal equipment that transmits and receives signals to and from the satellite. MSS user terminals can range in size from a hand-held, telephone terminal resembling a cellular telephone, to a suitcase-sized terminal, to a vehicular mounted terminal, with many variations in between. The size of the terminal is dictated primarily by the technical capabilities of the terminal and the radio frequency (RF) power output.

Control Segment

The control segment is responsible for operating the satellite and providing overall network management. It ensures that the satellite is maintained in the proper orbit, assigns transponders, adjusts power levels, allocates bandwidth, steers antennas, etc.

Space Segment

The space segment is composed of the satellite platform (the frame of the satellite) and the satellite payload (the operational service-providing equipment). The payload provides communications capabilities to the users.

What Types of Network MSS Architectures Exist?

Traditionally, commercial service satellites have used only one type of architecture to transmit and receive signals, the bent pipe architecture. Using this architecture, a satellite receives a signal, amplifies it, and sends the signal back. No call processing occurs within the satellite. Bent pipe systems require that the user and the gateway be in the same satellite footprint. The two types of satellite architectures are illustrated in Figure 2.

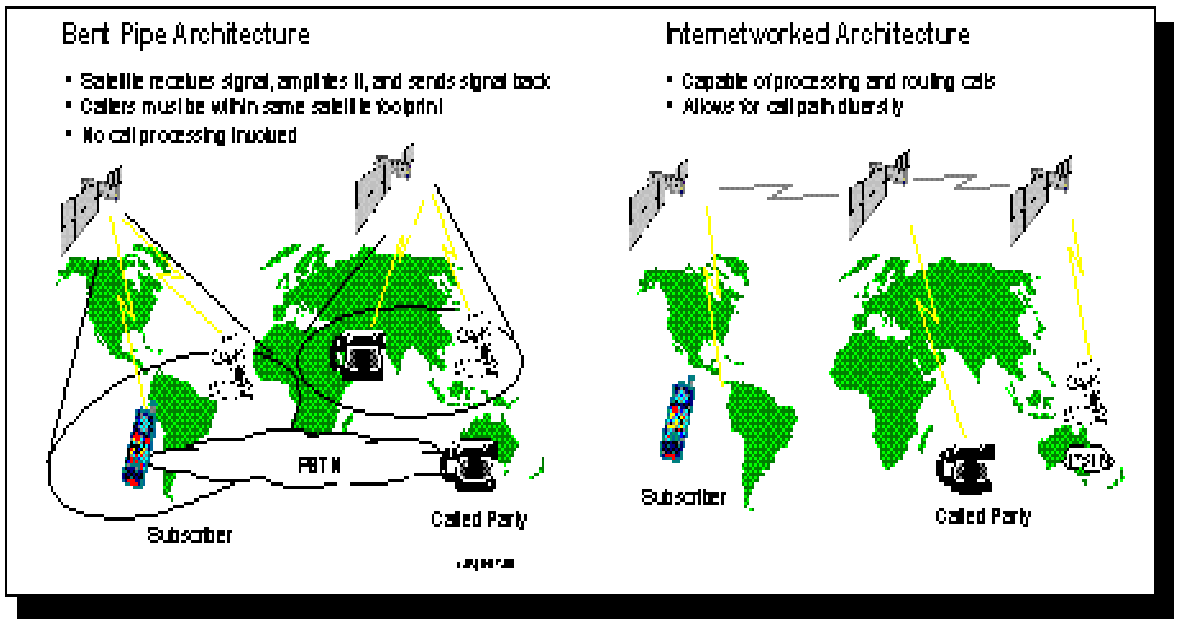

Figure 2
Bent Pipe vs. Internetworked Satellite Architectures

How Are MSS Systems Categorized?

MSS systems can be categorized by their orbital altitude: geostationary orbit (GEO), medium earth orbit (MEO), and low earth orbit (LEO).

Geostationary Orbit

A geostationary satellite system orbits approximately 22,300 miles (or 35,970 kilometers) from Earth. At this height and location, the satellite moves at the same speed as the Earth rotates. Thus, the satellite appears to be stationary in the sky. Geostationary satellites can provide coverage to a large portion of the earth using a small number of satellites (3 or 4). Because of the distance involved—it takes up to one second for a radio signal to travel from the earth to the satellite and return—Geostationary satellite systems have inherent transmission time delays and require terminal equipment with large RF power amplifiers.

Middle (or Medium) Earth Orbit

Medium earth orbits are located between 3,125 and 9,375 miles (or 5,040 and 15,121 kilometers) from the Earth. MEOs have lower orbits than GEO satellites, which reduces RF power requirements and transmission delays, but increases the number of satellites required to provide complete Earth coverage. A constellation of about 12 satellites can provide global coverage, which limits costs and reduces complex station-keeping needs.

Low Earth Orbit

LEO satellites orbit at altitudes between 500 and 1,250 miles (or 8,065 and 2,016 kilometers) from the Earth. LEOs have lower orbits than MEOs, which reduces RF power requirements and transmission delays when compared to MEOs and GEOs. LEO systems will use a constellation of many small, lightweight satellites circling the globe. LEO systems require many more satellites (from 20 to more than 100) to cover the earth. Over the next decade, it is projected that three-fourths of all new satellites launched will fly close to the Earth in low Earth orbit. LEO systems can be differentiated as either “little” LEOs or “big” LEOs. Little LEOs are designed for low-speed data services only, and big LEOs are designed to provide voice, data, and video services.

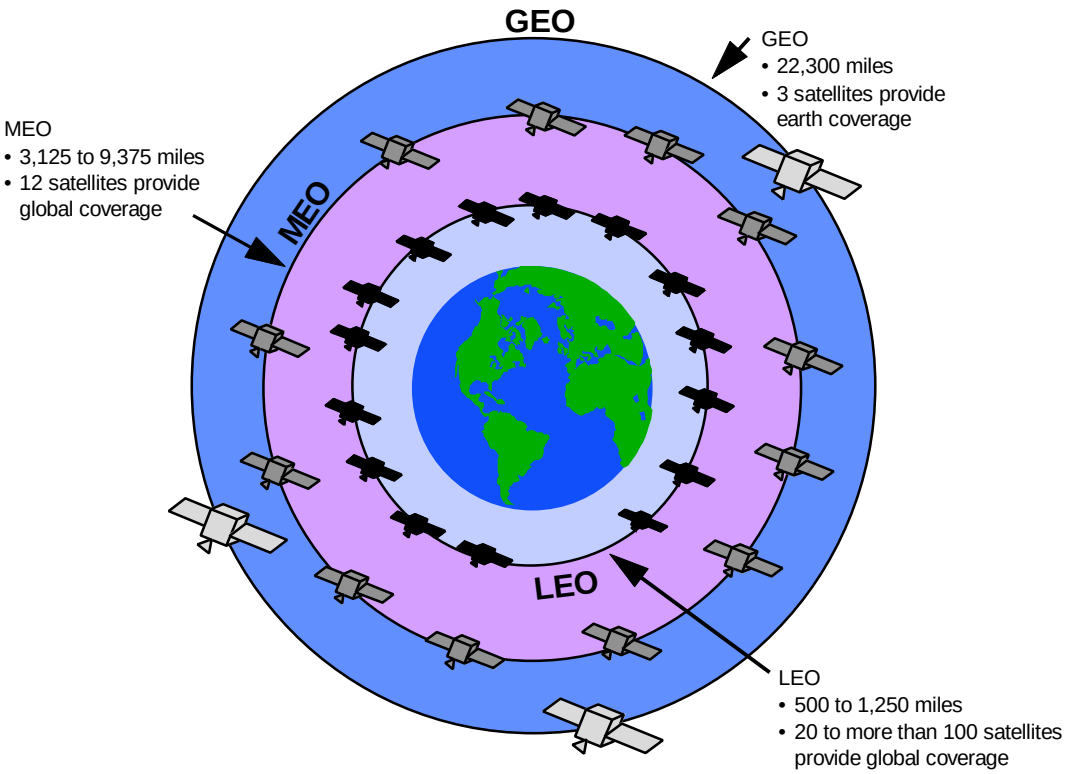

Figure 3
MSS Orbits

What MSS Systems Are Currently Available?

MSS systems currently offering mobile services include International Maritime Satellite (INMARSAT) and American Mobile Satellite System (AMSC), both of which are GEO systems.

International Maritime Satellite (INMARSAT) Organization

INMARSAT is an internationally owned cooperative (79 member countries) established in 1979 to serve the maritime community. INMARSAT has evolved to become a provider of global mobile satellite communications for use at sea, in the air, and on land. Each member government designates an in-country telecommunications entity, or signatory, to invest in the organization. Comsat Corporation is the U.S. signatory and the largest in terms of ownership. Land mobile communications conducted solely within the United States are no longer allowed by INMARSAT, because a domestic alternative, AMSC, now has an exclusive license.

From outside the United States, INMARSAT terminal users can place direct-dial telephone calls and send faxes, electronic mail, and digital data via INMARSAT's five operational GEO satellites. All communications are accomplished by the user's terminal transmitting up to the satellite and then down to a gateway, into the appropriate local or international phone system or to another terminal. Terminals can be adapted for vehicular mounting using dynamically driven antenna systems that can track a satellite regardless of vehicle movement.

INMARSAT offers several different mobile systems designed to provide users with a wide variety of terminals and services. The units and costs are illustrated in Figure 4.

	INMARSAT TERMINAL TYPE						
Feature	**A**	**B**	**C**	**M**	**Mini M**	**Aero-C**	**Aero-H**
Services	Voice/fax/ data	Voice/fax/ data	data	Voice/fax/ data	Voice/fax/ data	Data	Voice/fax/ data
Data Rate	56 kbps	64 Kbps	600 bps	4.8/2.4 kbps	4.8/2.4 kbps	600 bps	10.5 kbps
Weight	200 lbs	75 lbs	12 lbs	20 lbs	6 lbs	10 lbs	15 lbs
Size Comparison	Large suitcase	Suitcase	Laptop	Briefcase	Laptop	Laptop	Laptop
Number In Use	25,200	500	30,000	1,000	New Item	600	500
Terminal Cost Range	$25,000 to $35,000	$25,000 to $35,000	$5,000 to $8,000	$10,000 to $12,000	$3,000 to $5,000	$25,000 to $30,000	$150,000 to $200,000
Service Charges	$3-8 per minute	$2-6 per minute	$1.00-1.50 per kbit	$2-6 per minute	$3 per minute	$0.70-0.90 per kbit	$5-8 per minute

Figure 4
Standard INMARSAT Terminal Cost and Capabilities

American Mobile Satellite Corporation

The AMSC system provides coverage of the entire continental United States and 200 miles off shore, as well as Hawaii, the Caribbean, and portions of Alaska. The system, marketed as Skycell or Skycell Plus, can simultaneously support up to 228,000 subscribers with 1,500 voice channels of 6 kilohertz (kHz) spacing at a data rate of 6.75 kilobytes per second (kbps). Channels can be protected with STU-III, ANDVT, and KG-84 encryption devices.

The system provides integrated voice, fax, and digital data services. Services (data, multimode data, telephone, and voice dispatch) are offered as separate communications options that can be selected in any combination. A feature of the system is its digital broadcast dispatch capability. This allows a dispatcher to open a single voice channel and communicate with an individual user, a selected group of users, or all network users (up to 10,000). Each mobile terminal can be included in up to 16 talk groups of 10,000 subscribers per group. Users within a talk group can communicate via a one-way group call or through standard, two-way communications. Figure 5 illustrates Skycell Plus integrated network including all features and applications.

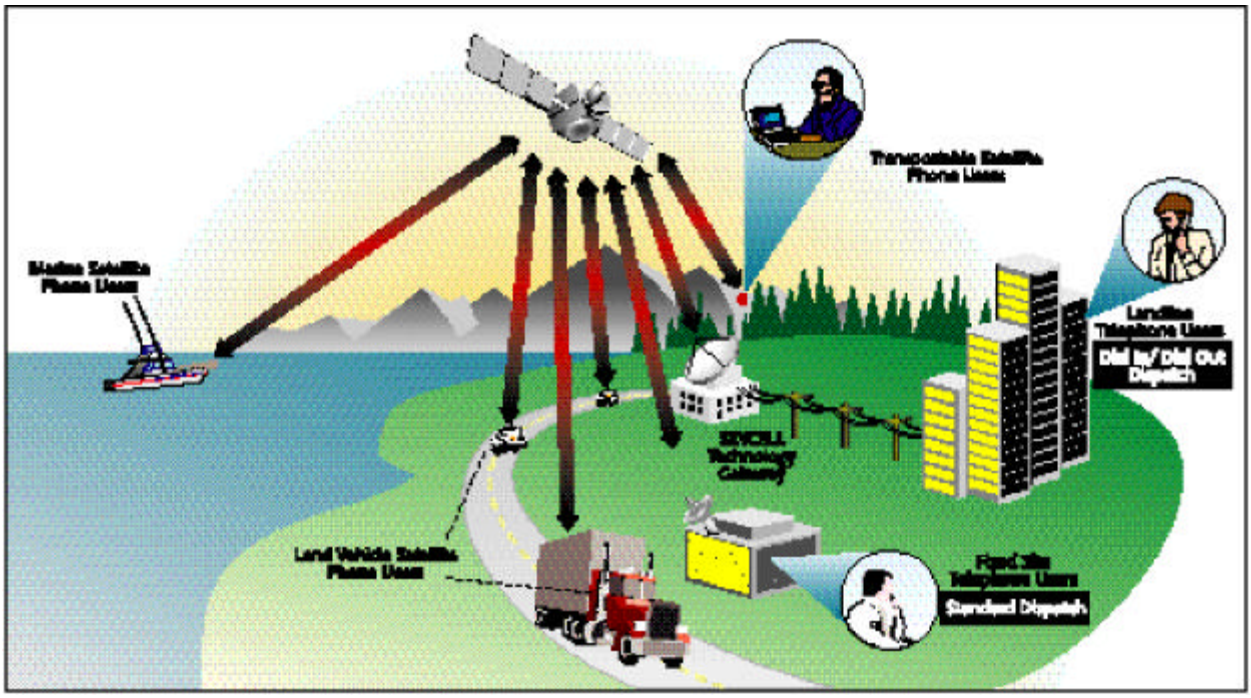

Figure 5
Skycell Plus Integrated Network

User terminal equipment for Skycell Plus is defined by application and varies with each application. The defined applications are Land Mobile, Transportable, Fixed Site, Aeronautical, and Maritime. Their capabilities and costs are shown in Figure 6.

	TERMINAL APPLICATION TYPE				
Feature	**Land Mobile**	**Transportable**	**Fixed Site**	**Aeronautical**	**Maritime**
Services	Voice/Fax/Data	Voice/Fax/Data	Voice/Fax/Data	Voice/Fax/Data	Voice/Fax/Data
Data Rate	2400 bps	2400 bps	2400 bps	2400 bps	2400 bps
Weight	10-13 lbs	28 lbs	15 lbs	38 lbs	17/37 lbs[1]
Terminal Cost	$2,200-$3,800	$3,000-$4,500	$2,900-$4,300	$19,000-$30,000	$5,700-$8,200
Service Charges	$0.95-$1.20/min	$1.20/min	$0.83-$1.20/min	$1.99/min	$0.95-$1.20/min
Manufacturers	Mitsubishi Westinghouse	Mitsubishi	Mitsubishi Westinghouse	Westinghouse	Mitsubishi Westinghouse

[1] Depends on which of two types of antenna is used.

Figure 6
Standard Skycell Terminal Cost and Capabilities

What New MSS Systems are Emerging?

The new generation of MSS systems that are expected to become operational in the next 2 to 5 years are MEO and LEO systems. Rather than using a small number of GEO satellites like those employed in the INMARSAT and AMSC systems, these new systems will consist of a constellation of many smaller satellite constellations located closer to Earth. It is not the intent of this report to provide a detailed description of every system being developed, but to provide generalities concerning the systems.

MEO Systems

Three MEO players proposing systems are Odyssey, ICO Global, and Ellipso. Their system capabilities are shown in Figure 7.

	SYSTEM NAME		
	Odyssey	**ICO Global**	**Ellipso**
Major Sponsor	TRW Teleglobe, Inc.	Intelsat	Mobile Communications Holding, Inc.
Capability	Fixed and Mobile Telephony	Voice, Paging, Fax Data, GPS	Voice, Paging, Fax Data
Orbit Shape	Circular	Circular	Highly elliptical
No. of Satellites	12	12	17
Altitude (km)	10,378 km	10,378 km	524 km - Perigee 7,903.7 km - Apogee
Operational Date	2001	2002	2000
Terminal Cost (Est.)	$500-$700	$2,000	$1,000
Usage Cost (Est.)	$.65 per min	$1-2.00 per min	$50.00 per month plus $0.50 per min

Figure 7
MEO System Cost and Capabilities

LEO Systems

There are a number of LEO systems currently under development. Figure 8 lists some general characteristics of four proposed LEO systems. Other proposed LEO systems include Starsys (24 satellites), Vita (3 satellites), E-sat (6 satellites), LEO One (48 satellites), GE Americom (24 satellites), GEMnet (38 satellites), Final Analysis (26 satellites), and ECCO (12 satellites).

	SYSTEM NAME			
	Iridium	**Globalstar**	**Orbcomm**	**Teledesic**
Major Sponsor	Motorola	Loral Qualcomm	Orbital Sciences Corp Teleglobe, Inc.	McCaw, Gates
Capability	Voice, Paging, Fax, Low Speed Data	Voice, Paging, Low Speed Data	Data Messages	High Speed Data, Video
Orbit Shape	Circular	Circular	Circular	Circular
No. of Satellites	66	48	36	288
Altitude (km)	679.9 km	1230.7 km	774.2 km	677.5 km
Operational Date	1998	1998	1999	2002
Terminal Cost (Est.)	$3,000	$700	$400	$1,000 for 64 kbps
Usage Cost (Est.)	$3.00 per min	$0.70 per min	$.25 per message	Undetermined

Figure 8
LEO Systems Cost and Capabilities

What are the Potential Benefits of MSS?

MSS will offer unique capabilities and features that can be used to enhance communications and to augment terrestrial-based wireless systems. Several key capabilities and features distinguish MSS from other wireless services:

- **Access Diversity**—A particular advantage of using satellite communications is that satellite networks can access terrestrial based communications networks via geographically dispersed gateways. Thus, should the local or regional terrestrial networks be damaged, MSS users should be able to access the PSN and other communications networks using entry points in undamaged areas.

- **Terrain Independence—**MSS can provide communications in areas where terrestial communications networks are not available.

- **Connectivity**—MSS will interconnect through satellite gateways with terrestrial-based networks via the PSN. In addition, service providers are discussing the possibility of providing dual-mode or triple-mode handsets that combine the features and functions of an MSS handset and cellular or PCS handset—thus providing seamless connectivity for the mobile user.

- **Priority Access**—Most MSS providers plan to offer some form of priority access scheme, although the specific details are not available at this time. It is likely that any priority treatment would be an added cost to the user.

What Are the Potential Limitations of MSS?

Although MSS systems will offer capabilities not available from current services, they do have some limitations:

- **Availability**—While the new generation of MSS systems are expected to offer a wide range of services applicable to public safety users, they are not expected to be fully operational until the year 2000 or later.

- **Line-of-Sight Requirement**—Satellite systems are susceptible to shadowing. This requires the user to maintain line-of-sight with the satellite for quality communications to occur.

- **Lack of Interoperability Between MSS Systems**—It is highly unlikely that MSS providers will establish direct interoperability with each other's systems. Each MSS provider can use different protocols, technology, and frequencies. Users that require access to multiple MSS providers will be required to obtain a terminal for each MSS service or use the PSN for interconnection.

- **Emerging Technology**—With the exception of INMARSAT and AMSC, MSS systems are still in the initial deployment stage. In fact, only a handful of MSS companies have satellites in orbit. Until MSS systems become fully operational, their actual capabilities are unclear.

How Can MSS Services Be Acquired?

Service packages and billing structures are likely to vary among systems. It is likely that each system will develop a set of customer service packages (similar to today's cellular/PCS service packages). MSS services may be offered directly through MSS providers or may be packaged with terrestrial cellular or PCS services. For all potential acquisitions of MSS services, users may elect to ask the following questions to better understand the attributes and costs of specific services:

- Do your requirements justify the need for MSS?
- Can you make a business case for MSS?
- What is the expected reliability of the MSS service in terms of availability, call completion, and voice quality?
- When I am quoted a per minute MSS rate, does that rate include only satellite airtime, with an additional long distance and PSN interconnect rate applied?
- If the system is packaged as a cellular/PCS–MSS packaged service, what are the two airtime and call rates?
- If the system is packaged as a cellular/PCS–MSS packaged service, at what threshold will the call be switched from the terrestrial network to the MSS network?
- Does the cellular/PCS–MSS package offer price breaks that are improved over purchasing strictly MSS services?
- How would you interconnect your MSS services with your terrestrial-based systems?
- Do you understand the capabilities and limitations of MSS?
- Is there priority access available? Do you require priority access?
- What are features and additional costs of priority schemes?

Appendix
LIST OF ACRONYMS

AMSC	American Mobile Satellite Corporation
FLEWUG	Federal Law Enforcement Users Group
GEO	Geostationary orbit
INMARSAT	International Maritime Satellite
LMR	Land mobile radio
LEO	Low Earth orbit
MEO	Medium Earth orbit
MSS	Mobile satellite service
PCS	Personal communications services
PSN	Public switched network
PSWN	Public Safety Wireless Network
RF	Radio Frequency